Physics 230

Homework Set 11

1. An object of mass $m = 0.55$ kg is attached to a spring of spring constant $k = 46$ N/m, hung from the ceiling, and allowed to oscillate in the vertical direction where the mass undergoes SHM. At time $t = 0$, the mass is displaced from the equilibrium position by 5.5 cm in the *downward* direction and is given an initial shove, imparting a speed of 0.45 m/s on the mass, also in the *downward* direction.
   a) Obtain an expression for the displacement of the mass in the form $x(t) = A\cos(\omega t+\phi)$, obtaining numerical values for A, ω and ϕ.
   b) Calculate the period of oscillation for the mass.
   c) Calculate the *total energy* of the oscillator.
   d) Calculate the *maximum speed* of the hanging mass.

2. Reconsider the oscillator of the previous problem whose motion is described by the solution found in 1.a). Using a spreadsheet program (i.e. Excel), plot this function over the time period $t = 0$ to 2.00s, with a time step no greater than 0.0200s. Your columns of input data must be labeled with the correct SI units. Your plot needs to include a title and the axes should be labeled and include units.

3. You decide to again oscillate the same spring subjected to the same mass specified in Problem 1), but this time the mass is given no initial stretch and only an initial shove. At time $t = 0$, the mass departs the equilibrium position with a speed of 1.1 m/s toward the *ceiling*.
   a) Again obtain an expression for the displacement of the mass in the form $x(t) = A\cos(\omega t + \phi)$, obtaining numerical values for A, ω and ϕ.
   b) Using a spreadsheet program (i.e. Excel), plot this function over the time period $t = 0$ to 2.00s, with a time step no greater than 0.0200s. Your columns of input data must be labeled with the correct SI units. Your plot needs to include a title and the axes should be labeled and include units.

4. Reconsider the oscillator of Problem 1 whose motion is described by the solution found in Problem 1.a).

   a) Calculate the time-dependent potential energy of the system, $U(t)$.

   b) Calculate the time-dependent kinetic energy of the system, $K(t)$.

   c) Using a spreadsheet program (i.e. Excel), plot $U(t)$ vs t, $K(t)$ vs t, and $U(t) + K(t)$ vs t, all on the same plot. Plot these functions over the time period $t = 0$ to 1.00s, with a time step no greater than 0.0100s. Your columns of input data must be labeled with the correct SI units. Your plot needs to include a title and the axes should be labeled and include units.

5. A simple pendulum consists of a pumpkin attached to a string of length of 16 m. At time $t = 0$, the pumpkin is displaced by an angle of 5.0° and given an initial shove *away from* the equilibrium position, imparting an initial speed of 1.0 m/s on the pumpkin.

   a) Obtain an expression for the angular position of the mass in the form $\theta(t) = \theta_0 \cos(\omega t + \phi)$, obtaining numerical values for θ_0, ω and ϕ in SI units.

   b) Calculate the period of the oscillation for the mass.

   c) What is the *maximum speed* of the pumpkin?

   d) What is the largest angle obtained by the pumpkin pendulum? Give your answer in degrees.